Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands	))))) ET Docket No. 03-237)))

Comments of Proxim Corporation

Summary

Proxim Corporation is a global leader in wireless networking equipment for Wi-Fi and broadband wireless networks. Proxim provides enterprise and service provider customers with wireless solutions for the mobile enterprise, security and surveillance, last mile access, voice and data backhaul, public hot spots, and metropolitan area networks.

As a company whose entire business is in the area of wireless communications, and for which the vast majority of that business is in the area of unlicensed wireless communications, Proxim considers no regulatory issues to be more important than those related to spectrum policy. Among those, the issue of spectrum sharing is of primary importance since we see it as a way to expand spectrum access for unlicensed devices. For this reason we are very encouraged to see the Commission exploring new mechanisms for spectrum sharing, such as cognitive radios, and the Interference Temperature [I.T.] concepts set forth in the instant Notice.[1] Proxim believes that the current mechanisms for spectrum allocation, which represent essentially a zero-sum method of spectrum assignment, will not suffice in the long term, and that more advanced, intelligent methods of spectrum sharing represent the future.

[1] "In the matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands", ET Docket No. 03-237, released November 28, 2003. Hereinafter, the "Notice".

In preparing comments for this Notice, Proxim created a simulation to represent the sharing of unlicensed devices in the presence of a licensed system. We hope that by entering our analysis into the record, we can advance the thinking around Interference Temperature. Based on our initial analyses, we have not been able to discover an efficient method for a sharing device to determine, based on measurements that it, itself, makes, whether or not it can transmit without causing harmful interference.

Analysis

To understand how I.T. could be used as a spectrum sharing methodology, we set up a very simple simulation in which some "sharing devices" attempt to use the I.T. concept to share spectrum with a "licensed system." A circular area is covered by a single transmitter (a base station) transmitting to a number of mobile devices (subscribers). This constitutes what we refer to as the "licensed system." The sharing devices are independent transmitters, located somewhere in the licensed system coverage area. For our simulation, the parameters we used were:

Licensed System	
Base Station Transmitter Power	30 dBm
Subscriber Transmitter Power	20 dBm
Licensed Device Bandwidth	20 MHz
Licensed Device Minimum C/(I+N)	12 dB
Sharing System	
Device Transmitter Power	20 dBm
Device Bandwidth	20 MHz
Path Loss	
Frequency	2000 MHz (TDD – all transmissions at this frequency)
Free Space up to break point of…	50 meters
After break point, exponent of…	4

Table 1: Simulation Parameters

There are many elements of a more complex model that are not included in this simple model, but the objective was first to demonstrate how I.T. could be used to share spectrum in a trivial example. We asked the question of how a sharing device could determine, based on any local measurement that it could make, that it was in an area in which the RF energy it would create would be an acceptable source of interference. That is, we took as our model for the I.T. operation the methodology described in the Notice as: "In the simplest case, the entire process would take place within an individual device. That is, the device would measure the interference temperature at its location and make a transmit/not transmit decision based on this measurement plus the device's own contribution of RF energy. If the result of this analysis were below the interference temperature limit set for that location, the device would transmit."[2]

Using the parameters above, a representative configuration is as shown in Figure 1. The green (filled) circles are the sharing devices, and the red (open) circle is the licensed subscriber. There is only one licensed subscriber, and 10 sharing devices. The base station for the licensed system is at the center of the large circle.

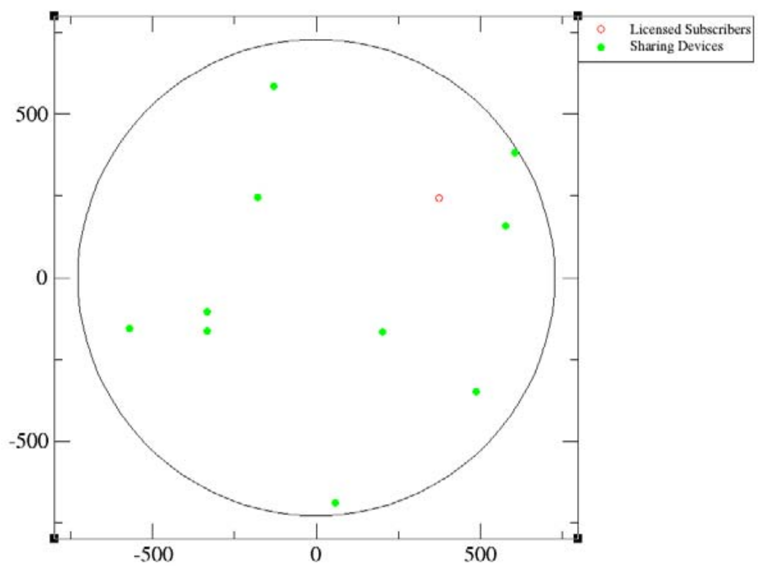

Figure 1: Representative Sharing Scenario

For reference, the large circle represents the coverage area of the licensed system. At 2 GHz, r^4 propagation with a break point at 50 meters has 119 dB of path loss at 729 meters. This 119 dB of path loss means that at the edge of this circular area, the received

[2] Notice at ¶11.

signal will be 30 dBm – 119 dB = -89 dBm, which is the required threshold value. (Thermal noise for this 20 MHz receiver is –101 dBm, so the C/N value[3] is –89 - –101= 12 dB.)

In the simulation, it is possible to determine the region within which a single sharing transmitter (at 20 dBm) would *not* cause harmful interference to the licensed subscriber. That is, we can identify the region in which, if a sharing transmitter were active, the licensed subscriber would still have a C/(I+N) value[4] in excess of the required 12 dB. This area, the "allowed sharing area", is shown in Figure 2.

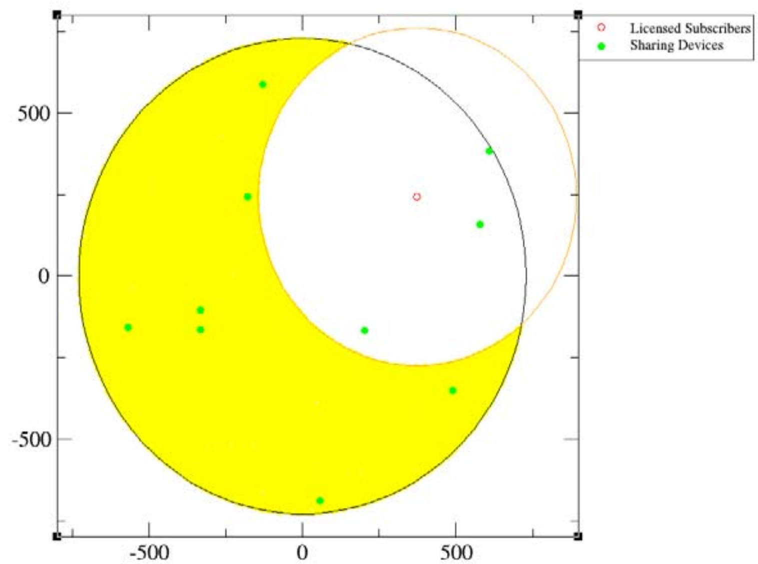

Figure 2: The allowed sharing area is highlighted

What we see is that there is a circular "keep away" region around the licensed subscriber (that region has been highlighted by a solid circle, for clarity.) This "keep away" region is the region within which a sharing device (at the given transmitter power and propagation law) would raise the interference level at the licensed subscriber beyond the permissible limit. That is, the licensed subscriber's C/(I+N) value would fall below the threshold. So the "allowed sharing" area is the highlighted area outside of this "keep

[3] Carrier-to-Thermal-Noise ratio.

[4] Carrier-to-Interference-plus-Thermal-Noise ratio.

away" region. Once this area has been determined, it is then possible to identify the sharing devices that could, in principle, safely transmit without creating harmful interference to the licensed subscriber. These sharing devices are identified in Figure 3.

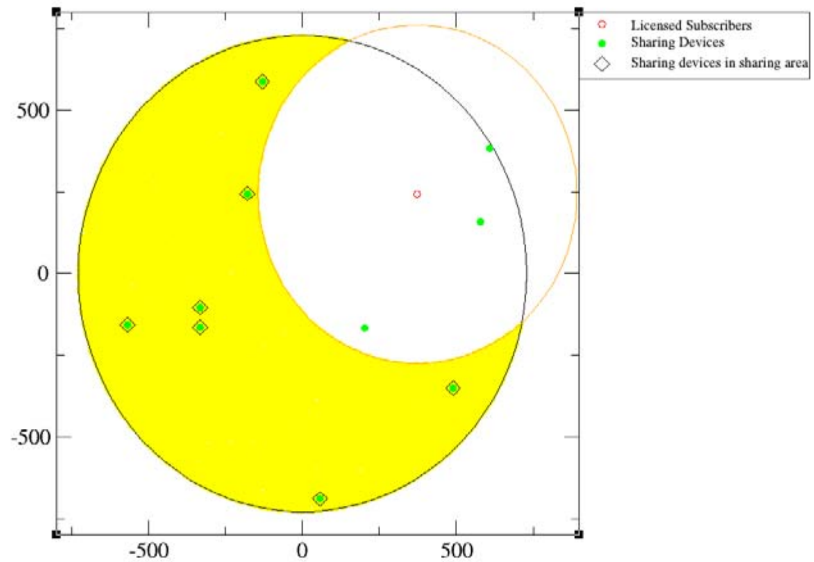

Figure 3: Sharing Devices in allowed sharing area

The question we ask then is "What could these devices measure independently to determine that they were, in fact, within the sharing area?" So far, we only know that they are within the sharing area because this is a simulation.

Clearly, measuring the received signal from the base station (located at the center of the large circular region) tells these devices nothing, since devices in the sharing region and outside the sharing region have a similar distribution of distance from the base station. This, though clear from Figure 3, is also shown by examining the distribution of signal strength received by the sharing devices *from the base station alone*. As is clear in Figure 4, there is no distinguishable difference between the base station signal received by a device within the allowed sharing area, and the base station signal received by a device outside of the allowed sharing area.

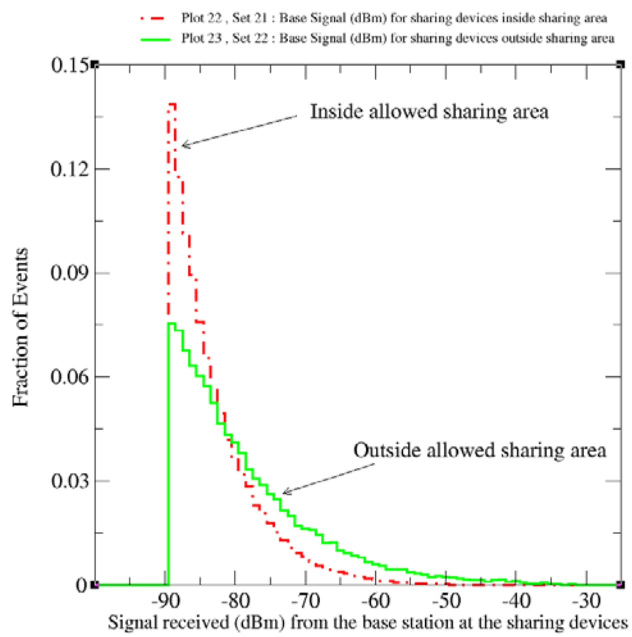

Figure 4: Signal from the base station received by the sharing devices

Using the concept of "Interference Temperature", Figure 4 can also be expressed in terms of the temperature at each sharing device caused by the base station.

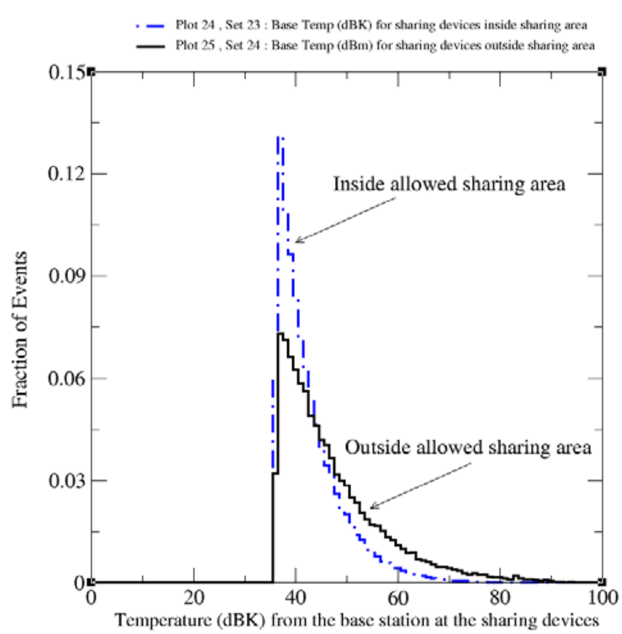

Figure 5: Temperature at the sharing devices caused by the base station (dBK)

As both Figure 4 and Figure 5 make clear, there is very little difference between the temperature from the base station at a sharing device inside the sharing area, and the temperature from the base station at a sharing device outside the sharing area.

It can be understood by examining the scenario in Figure 3 that it is the signal *from the licensed subscriber unit* that tells the sharing devices whether or not they can transmit. Devices close to the licensed subscriber will cause too much interference, and will push the C/(I+N) value below the required minimum. That is, the sharing devices must use some indication from the licensed subscriber to determine whether or not it is inside the "keep away" region.

Assuming that these licensed subscribers are transmitting devices, it appears that the sharing devices must monitor the spectrum long enough to measure not only the signal from the base station, but also the signal from the subscriber itself. (This assumes that those devices are transmitting, as well as receiving, devices.) In the simulation, the signal received by the sharing devices from the licensed subscriber can be isolated, and this is shown in Figure 6.

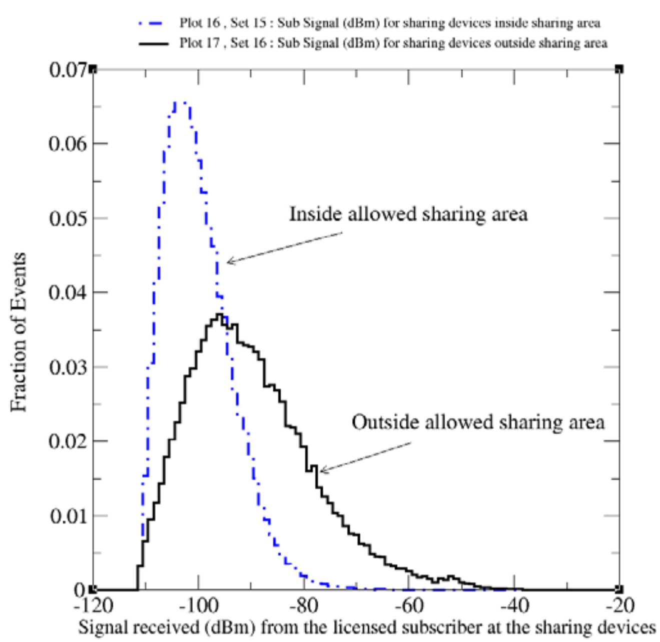

Figure 6: Signal from the licensed subscriber at the sharing devices

Expressed in terms of interference temperature, this data is shown in Figure 7.

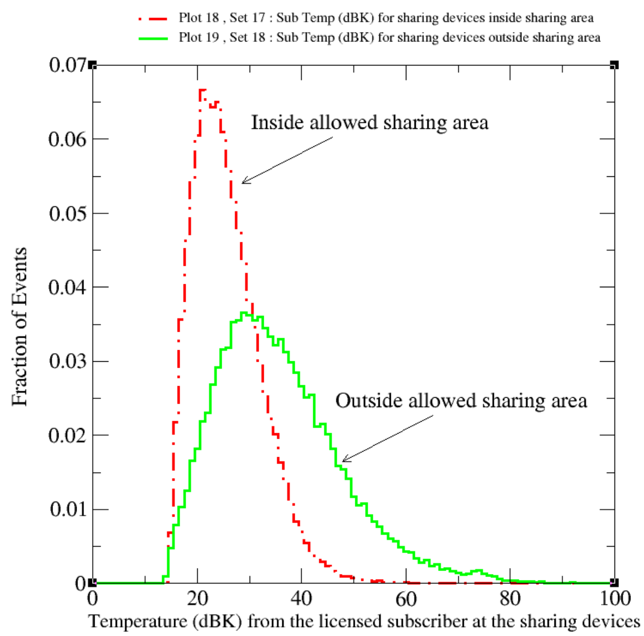

Figure 7: Temperature at the sharing devices caused by the licensed subscriber (dBK)

Figure 6 and Figure 7 show that the devices in the sharing area do have a lower temperature from the sharing subscriber, on average, than those devices outside of the allowed sharing region.

The problem, however, as can also be seen from these figures, is that the differentiation between the sharing devices in the allowed region, and those outside the allowed region is not very significant. That is, even in this very simple simulation it is not possible, based solely on a temperature measurement made by the sharing devices themselves, to distinguish clearly between devices which will cause interference, and those which will not. There is no simple I.T. level (say, 30 dBK) at which a device could reasonably conclude that it was either inside, or outside, of the allowed sharing area. If, for example, 30 dBK were taken to be the sharing limit, nearly 80% of the sharing devices in the allowed area would conclude that they could safely transmit. However, nearly 40% of the sharing devices within the “keep away” region would conclude the same thing.

The problem we have identified here shows a fundamental problem in the use of the interference temperature concept. That is, there is no good way for a sharing device to determine, based on a measurement of its own environment, if it will interfere with another device in its range. And this simulation is a very simplistic one. Adding more complex effects, such as signal fading, would case even more uncertainty. And the worst of all possible situations would be one in which the subscribers were not transmitting at all.

In addition, the simulation discussed so far represents a very artificial environment. Increasing the number of licensed subscribers will, of course, reduce the "allowed sharing" area. For example, a representative deployment with five licensed subscribers is shown in Figure 8.

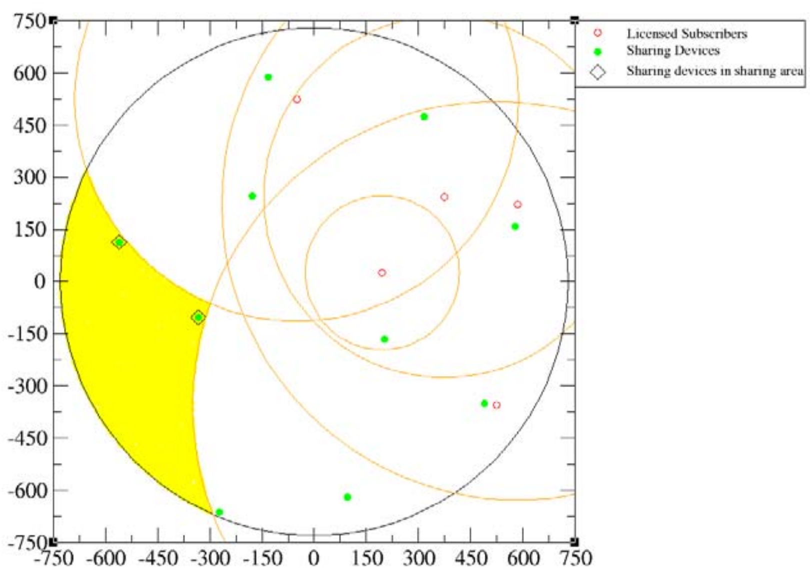

Figure 8: Representative scenario with five licensed subscribers

The allowed sharing area has shrunk dramatically (this is caused by the combined effects of the "keep away" regions, highlighted, again, with solid circles), and with 10 subscribers, it disappears completely. So as the number of licensed subscribers increases there is no location at which a sharing device could transmit without causing harmful interference to a licensed subscriber.

If the transmitter power of the sharing devices is reduced (in this case from 20 dBm to 0 dBm) the area available for sharing increases, as shown in Figure 9. This version of the simulation has 10 licensed subscribers, and 50 sharing devices.

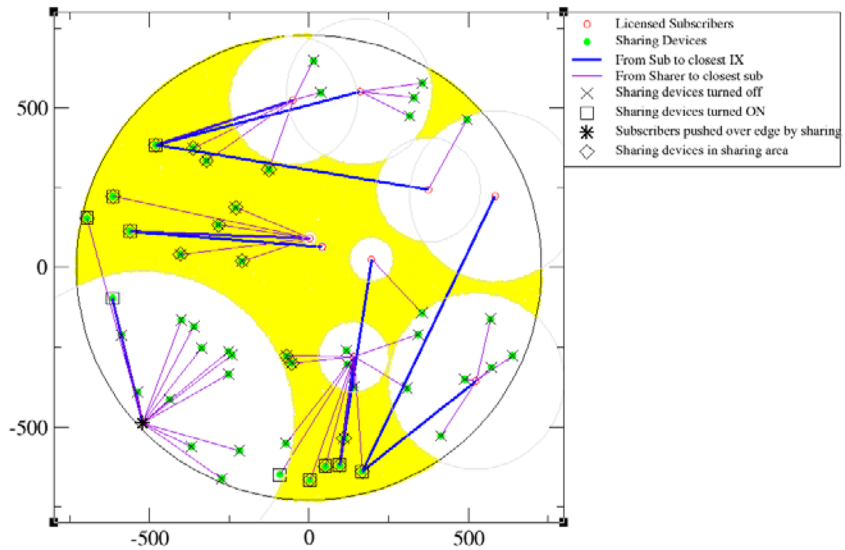

Figure 9: Simulation with low-powered sharing devices

Yet, even though there is more opportunity for sharing, measuring interference at the sharing devices remains in inefficient way to identify sharing opportunities. For example, in this case, with a 30 dBK threshold only 20% of the sharing devices are permitted to transmit, and even then 10% of the licensed subscribers are subjected to harmful interference. Increasing the temperature threshold to allow more sharing would only increase the percentage of licensed subscribers experiencing harmful interference.

Conclusion

The result of our analysis so far is that the most straightforward method of using the Interference Temperature concept, in which devices make local measurements that determine the transmit/no-transmit decision, is fraught with difficulty. The main problems are:

1. Local measurements made by a sharing device cannot determine accurately whether or not such a device will cause harmful interference to a licensed subscriber.
2. Any attempt to use a strict temperature cutoff to protect the licensed subscribers will also severely limit the ability of the sharing devices to transmit.
3. The best chance of making a useful measurement is to measure the signal from the nearby subscribers. This can only happen if the receivers are also transmitters, which may not always be the case.

The Notice also suggests other ways in which the I.T. concept might be effective, and we have not yet simulated these other methods. For example, the Notice offers that:

> "Another approach would be for the receive sites of a licensed service to measure the temperature and communicate those measurements to a central site, where the interference temperature profile for the region would be computed. A message could then be broadcast indicating the temperature values over that region and perhaps whether devices would or could not transmit on particular frequencies. This scenario may be appropriate in services such as those involving fixed point-to-point operations where there are relatively few receive sites in a given area. A third more general case, might be to establish a grid of monitoring stations that would continuously examine the RF energy levels in specified bands, process that data to derive interference temperatures, and then broadcast that data to subject transmitters on a dedicated frequency, again perhaps with instructions how to respond. The transmitted temperature data from this monitoring system could also include the frequency and geographic location of the interference temperature measurement(s) and the measurement bandwidth so that an individual device could compute the rise in temperature due to its own contribution and make a decision to transmit."[5]

These other methods may address the concerns raised in our simulation. However, they are also much more complex procedures to implement, involving central coordinators, location capability, and possibly grids of RF monitoring devices. Simulating these scenarios may not be too complicated, but implementing any such solution is certain to be very complicated.

Proxim recommends that the I.T. concept will take more study before it can be successfully implemented. We will continue to pursue our investigations and to offer to the Commission whatever insights we have.

Respectfully Submitted,
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Proxim Corporation

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[5] NOI ¶11 and ¶12.